American
POTATO JOURNAL

Volume 33 ***June 1956*** ***Number 6***

CONTENTS

NEWS AND REVIEWS

Official Publication of
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, NEW JERSEY, U. S. A.

American Potato Journal

PUBLISHED BY
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, N. J.

Price $4.00 per year in North America; $5.00 in other countries.

Entered as second class matter at New Brunswick, N. J., March 14, 1942 under Act of March 3, 1879. Accepted for mailing at special rate of postage provided for in section 412, Act of February 28, 1925, authorized on March 14, 1928.

DEPRESSION OF POTATO YIELDS BY BORDEAUX MIXTURE DURING A DRY SUMMER[1]

J. D. Wilson and J. P. Sleesman[2]

Introduction

The tendency of Bordeaux mixture to cause various types of plant injury and to depress crop yields has been recognized by the authors and by numerous plant pathologists for many years (1, 2, 3, 4, 5, 10, 11, 12, 13, and 14). However, in spite of the possibility that such host injury may occur, Bordeaux is widely used as a fungicide for the control of many different plant diseases. This is chiefly because of its excellence as a fungicide, combined with a high degree of chemical and physical stability, and its durability (adhesiveness) on the foliage to which it is applied.

Previous to 1930 recorded observations relative to the physiological effect of Bordeaux mixture on various crops were about equally divided between those that were thought to reflect a beneficial and/or negative reaction of the host to the spray material and those that were suspected of being injurious (1, 3, 6, 7, and 10).

During the severe summer drought of 1930 in Ohio, the senior author observed a very striking example of the injurious effect which Bordeaux may have on plants being sprayed with it for disease control. Ginseng growing in a woodlot was being treated with various fungicide formulations for the control of Alternaria leaf spot. The soil-moisture content became so low that the ginseng plants (as well as numerous other species) wilted periodically on hot, sunny days. A few days after this wilting began the leaves in the plot being sprayed with Bordeaux mixture began to wither and die, whereas those in adjacent unsprayed plots and others treated with other materials always recovered each evening from their daytime wilting to remain comparatively normal in appearance until fall (10). Since 1930 Wilson (12, 13, 14, 15, and 16) and Horsfall (3, 4), among others, have reported several instances in which Bordeaux was observed to be definitely injurious to various crop plants, especially at the time they are small, highly vegetative, and/or during periods of hot, dry weather when the soil-moisture content is low or deficient.

Cucumbers and tomatoes are among the vegetable crops most susceptible to Bordeaux injury, whereas celery and potatoes are much less likely to be affected unfavorably, even during dry weather. One indication that Bordeaux may affect even potato plants unfavorably was observed by the authors several years ago (15) when plants sprayed with this fungicide had less than half as many blossoms as did those sprayed with zineb. Also, the fact that potato vines sprayed with Bordeaux mixture often mature and die sooner than those treated with zineb, is probably an indication that they have been injured to some degree by the former. Another form of injury associated with the presence of copper on foliage has been observed in the growth shredding of ginseng leaves sprayed with Bordeaux during periods of near freezing temperatures, and in an

[1]Accepted for publication November 22, 1955.
[2]Plant Pathologist, and Entomologist, respectively, Ohio Agr. Exp. Sta., Wooster, Ohio.

instance reported by the senior author (16) in which potato and tomato plants sprayed all season with copper-containing fungicides were frozen more severely by a marginal frost (near-killing) than were those in adjacent plots that had been sprayed with various dithiocarbamate (zinc-containing) fungicides.

The results of spraying potatoes with this fungicide for the control of diseases (and insects) in Ohio have been reported in several instances (7, 8, 9, 15, and 16). It is seldom that a decrease in yield below that of the untreated check plots has been observed in spraying potatoes, although this circumstance has been noted several times with tomatoes (11, 13) when plant injury was a factor in reducing yields. As a general rule, soil moisture is plentiful enough so that a small increase in the rate of water loss and in the water requirement of the potato plant as brought by the presence of Bordeaux on the foliage, does not result in the decrease in yield. However, this did occur in 1954 in an experiment at Wooster and a discussion of this rather unusual circumstance represents the subject matter of this paper.

Fewer and fewer potatoes were sprayed with Bordeaux mixture each year in Ohio from approximately 1942 to 1950 as the use of such organic fungicides as the dithiocarbamates became more and more general. However, it should be mentioned that only recently there has been a partial revival in the use of copper-containing fungicides, including Bordeaux mixture, where they have been used near the end of the season on the late-maturing portion of the potato crop in an effort to hasten the maturity of plants sprayed during most of the summer with organic fungicides, and at the same time to afford a maximum degree of protection against the possible development of late-blight tuber rot.

During recent years, beginning with the advent of the dithiocarbamate fungicides such as ziram, zineb, and maneb, and of DDT as an insecticide, together with the concomitant development of the potato chip industry, there has been a growing tendency among growers, processors, and even the consumer, to hold the change in the spray program from copper-containing formulations to the organic compounds responsible for all real and/or imaginary decreases in potato quality. If the organic fungicides and insecticides do have any unfavorable effect on the chipping quality of potatoes, which is somewhat questionable, then it is most likely due to the fact that their use does extend the growth period and delay the maturity date somewhat beyond that which has been accepted as the normal for unsprayed or Bordeaux-sprayed potatoes. This means that the tubers are also less mature on the greener vines and consequently may be of lower specific gravity than they would have been on more nearly mature plants, although even this assumption is not always borne out by actual determinations of specific gravity on specific dates preceding complete death of the vines in differently sprayed plots, as will be shown later. It was in an effort to determine and identify any possible effects of the spray program on the cooking and chipping quality of potatoes that an experiment, some of the data from which are discussed here, was initiated cooperatively in 1953 by the Plant Pathology, Entomology and Horticultural Departments of the Ohio Agricultural Experiment Station.

Procedure

Katahdin potatoes were planted in 1953 and the differently treated plots were harvested and processed according to the various techniques and procedures commonly prescribed in such an experiment. No very striking results relative to yield or quality values were forthcoming during that year. However, the results were somewhat out of the ordinary in 1954 and some of these will be considered in this paper.

Rural Russet and Katahdin potatoes were planted the first week in June of 1954 on the Station farm at Wooster. The spray treatments listed in table 1 were begun on June 25 and continued until September 16. Twelve replicates were provided for each treatment on each variety. These replicates were so arranged in the plot design that four of them could be dug on three successive harvest dates without damaging those to be harvested later. The data with respect to yields and the specific gravity of different lots of potatoes are given in the table mentioned above.

The treatments used were selected to check the possible influence of DDT and of zineb (Dithane Z-78 in this instance) on yield, specific gravity, processing quality, *etc.* The need for an untreated check (Treatment 1) requires no explanation. Bordeaux mixture without an insecticide (Treatment 2) was included to afford an opportunity of comparing it with a formulation containing DDT (Treatment 3). Since DDT used alone failed to give satisfactory control of flea beetles in 1952 and 1953 in Ohio, dieldrin was mixed with it (2 parts of 50 per cent DDT and one part of a 50 per cent dieldrin wettable powder formulation) and the mixture was then used in a 1-100 spray formulation applied at 150 gallons per acre. The commonly used zineb plus DDT formula (Treatment 4) was used for the purpose of comparison with treatment 3. These three treatments (Numbers 2, 3, and 4) were used throughout the season without change. The possible effect of DDT on the tubers was partially checked by dropping it from treatment 5 at mid-season. Treatment 6 consisted of Number 4 for 5 applications after which it was replaced by Number 3 for the remainder of the season. Treatment 7 was similar except that Number 4 was used for 7 applications after which Bordeaux only (Treatment 2) was substituted to simulate possible grower practice in which a similar combination of treatments may be used to hasten maturity and provide better protection against late-blight tuber rot.

It was expected that the untreated check would have lost virtually all of its foliage by October 15 (135 days after planting), but because of a lack of early early-blight infection and only slight damage from flea beetles and leafhoppers, the "check" plots were only slightly less green at the end of the season than were most of the differently sprayed plots. As mentioned earlier, it was planned to use three harvest dates spaced at 2-week intervals to study the relationship between spray treatments and degree of maturity at harvest on quality features. Yield data were originally of only minor interest in this investigation, but the decrease brought about by the use of Bordeaux mixture, as shown in table 1, was considered worthy of note in this instance, chiefly because it demonstrates again the unfavorable effect that the use of this fungicide may have on plant growth in the absence of sufficient soil moisture to maintain optimum growth. Actually the rainfall at Wooster for the months of June, July,

August, and September of 1954 was only half the normal expectancy, being only 7.6 inches compared with a 60-year average of 14.4 inches, with a deficiency of slightly more than 2 inches in June and July and a little over one inch in August and September.

Under these conditions of low soil moisture content there was visible wilting of the vines on some days, and the tubers of the Russet variety showed a marked degree of secondary growth. The plants of both varieties that had been sprayed throughout the season with Bordeaux (Treatments 2 and 3 in table 1) were much more prostrate in growth habit than were those of the untreated checks and the zineb-sprayed plots. Also the leaves that received Bordeaux were definitely smaller and more cupped than those treated with zineb.

Results

At the time of the first harvest (September 16), when four replicates of each treatment were dug, representing one-third of the planting, there was little difference in the degree of maturity or in the percentage of defoliation of the differently treated plots in either variety. None of the vines had lost more than a small percentage of their leaf area at the time from disease or insect attack.

It is interesting to note (Table 1) that the average specific gravity for the tubers from the definitely immature Katahdin vines was higher than it was from later harvests (1.0852 for September 16 as compared with 1.0838 on October 1 and 1.0823 on October 14). The differences in specific gravity for the differently treated plots, as determined just after each harvest, were not significant in either variety. It was later shown by data collected in the Processing Laboratory of the Horticultural Department that there was no appreciable difference in the chipping quality of the tubers from the three different harvests with either Katahdin or Russet. However, the yields did increase with each successive harvest, as would be expected so long as the foliage remained in good condition. A smaller yield from the Bordeaux-sprayed plots than from the untreated checks was evident in the first harvest for both varieties, and this difference increased in the second and third harvests. Furthermore, it should be noted that only treatment 4 produced a yield equal to that of the unsprayed check plots. In all of the treatments that included Bordeaux, in all or part of the applications, there was some decrease in yield, as indicated in the averages for all three harvests.

The Russet variety matured somewhat more slowly than Katahdin and showed a larger decrease in yield due to the presence of Bordeaux on the foliage as the season progressed. The increase in yield of the untreated Russets from September 16 to October 14 was 50 per cent (Table 1), whereas those treated with Bordeaux (Treatments 2 and 3) increased only 34 per cent in yield in the same period, and finished with a yield that was about 60 bushels per acre, or nearly 20 per cent, less than that of the untreated plots. These yield differences were not as great percentagewise with Katahdin, being only about 8 or 9 per cent. The decreases in yield with Bordeaux as compared with the check plots on the different harvest dates were 14, 13, and 24 per cent on September 16, October 1 and October 14, respectively, and the corresponding differences with Katahdin were 6, 8, and 11 per cent. The over-all yield patterns are very similar for

TABLE 1.—*Yield and specific gravity data for Katahdin and Rural Russet potatoes sprayed with various formulations of Bordeaux, Dithane Z-78 and DDT + dieldrin.*

Treatments		Yields in Bus./Acre				Specific Gravity Values = 1.0—			
		Sept. 16	Oct. 1	Oct. 14	Ave.	Sept. 16	Oct. 1	Oct. 14	Ave.
Katahdin									
1. No treatment		321	360	429	370	859	838	823	840
2. Bordeaux only	8-4-100	312	338	366	339	827	830	837	831
3. Bordeaux + D-d*	8-4-1-100	291	320	395	335	844	838	812	831
4. Dithane Z-78 + D-d (All season)	2-1-100	315	370	436	374	873	832	820	842
5. No. 4 = 5 appl.—Then no D-d		308	374	403	362	838	871	836	848
6. No. 4 = 5 appl.—Then No. 3		302	348	383	344	857	834	830	840
7. No. 4 = 7 appl.—Then No. 2		296	343	394	344	866	825	803	831
Averages		305	350	401	352	852	838	823	838
Russet									
1. No treatment		266	325	403	331	873	795	799	822
2. Bordeaux only	8-4-100	226	284	319	276	859	826	791	825
3. Bordeaux + D-d*	8-4-1-100	230	281	293	268	840	815	798	818
4. Dithane Z-78 + D-d (All season)	2-1-100	261	338	387	329	843	864	801	836
5. No. 4 = 5 appl.—Then no D-d		251	334	377	321	844	839	808	830
6. No. 4 = 5 appl.—Then No. 3		248	302	319	290	860	838	777	825
7. No. 4 = 7 appl.—Then No. 2		241	310	330	294	833	853	775	820
Averages		246	311	347	301	850	833	793	825

*D-d This symbol represents a mixture of DDT and dieldrin which in this instance consisted of 2 parts of DDT (WP 50) and 1 part of dieldrin (WP 50).

the two varieties with the untreated checks dropping slightly below the Dithane-treated plots on October 1, but outyielding them on September 16 and October 14. The substitution of Bordeaux for Dithane in mid-season resulted in a decrease in yield below the all-season use of Dithane in all instances, but the total depression in yield below the check plots was less than with the use of Bordeaux throughout the season.

An average of the yields for the two varieties may give a slightly more significant index of the action of Bordeaux mixture as a yield depressant in this experiment. These average values show that the application of 12 Bordeaux sprays from June 25 to September 16 brought a reduction of about 45 bushels per acre, or about 12 per cent. When five applications of Dithane were made by July 26, and these were followed by seven of Bordeaux (Treatment 6) the reduction was slightly less at 33 bushels per acre, or about 10 per cent below the untreated check. There is some indication that the greatest effect of Bordeaux on the final yield occurred between August 16 and September 16, since the percentage of decrease was 10 per cent on September 16, about the same on October 1, but this had increased to 18 per cent by October 14.

The use of an insecticide with Bordeaux had little effect on yield and neither decreased injury caused by the fungicide nor gave enough additional control of a low insect population to bring about a yield increase. However, when the insecticidal portion of treatment 4 was dropped in mid-season, as it was in treatment 5, there was an average reduction in yield of 12 bushels per acre with Katahdin and 8 with Russet.

Reference should be made to the specific gravity values of these differently sprayed and harvested plots, chiefly because they were somewhat unusual and therefore different from what one might expect. First, as was mentioned earlier, the specific gravity values did not increase with an increase in maturity of the tubers on the successively later harvest dates. Instead they actually decreased somewhat, being definitely lower in the averages for all treatments on October 14 than on September 16. Also, the average specific gravity values of the tubers from Dithane-sprayed vines was no lower than those treated with Bordeaux, in fact they were slightly greater, and neither lot was appreciably different from those of the unsprayed check plots.

Therefore, up to the time of final maturity at least, tubers from vines sprayed with Dithane were no different in this experiment than those from plots treated with Bordeaux. Furthermore, on the basis of specific gravity values, which are commonly accepted as one measure of chipping quality, there was nothing to choose between potatoes sprayed with Bordeaux or with an organic fungicide.

In addition to the treatments listed in table 1, six others were included in another portion of the same field in a further comparison of organic and copper-containing spray formulations. One of these was Tribasic + D-d (4-1-100), which was applied to both Katahdins and Russets. Only the October harvest was provided for in this series. In the compilation of these data the Tribasic-sprayed plots yielded only one bushel per acre less than the unsprayed checks. Therefore a fixed copper fungicide failed to cause a depression in yield during a dry summer, whereas the use of Bordeaux brought about a reduction of at least 45 bushels per acre under the same environmental conditions. At the same time a tank-mix

formulation of ziram (SDD + $ZnSO_4$ + D-d, 2-1-1-100) gave a slightly higher yield than did Tribasic.

The average specific gravity value for the untreated check, Tribasic, and ziram plots in this portion of the experiment were 1.0775, 1.0817, and 1.0798, respectively. Therefore, with such small differences in specific gravity for the differently treated plots, it seems unlikely that potato quality was appreciably affected, either favorably or unfavorably, by the use of copper-containing and organic fungicides under the conditions of this experiment.

Data relative to various criteria of chipping quality as they are influenced by spray practices in this and several other similar experiments will be published later.

Summary

Potatoes have been sprayed each summer for the past few years with Bordeaux mixture, DDT, zineb, and combinations of these materials in an effort to discover any possible influence they may have on chipping quality.

Yield data in these experiments have been of only minor consideration during most seasons, but in 1954 when rainfall was only about one-half the usual expectancy for Wooster, and temperatures and evaporation rates were high, it was found that the plots being sprayed with Bordeaux yielded less than the untreated checks, or those sprayed with zineb (Dithane X-78).

This was of considerable interest to the authors since this was an instance of apparent Bordeaux injury to a crop which has always been considered comparatively resistant to the various types of injury caused by this fungicide on other vegetable crops, such as cucumbers and tomatoes.

In 1954, Katahdin and Russet potatoes were sprayed 12 times at weekly intervals. One-third of the planting was harvested on each of three different dates spaced at 2-week intervals — the first being on September 16 when the potatoes were definitely immature and the last on October 14 just after a frost had killed the vines. Disease and insect damage was scarce with all treatments, and even the untreated check plots showed only mild defoliation on October 10.

The depression in yield below the unsprayed plots, caused by the presence of Bordeaux on the foliage, became progressively larger with each harvest, until by October 14 the plots treated with it yielded 110 bushels per acre less than the untreated checks with Russets and 34 bushels with Katahdin. In each instance in which Bordeaux was used to replace zineb at mid-season, or near the end of the spray period, there was at least some depression of yield below that of the plots treated throughout the season with zineb.

There was no significant difference in the specific gravity of the tubers from the differently sprayed plots. Also, contrary to what usually happens, there was a noticeable decrease in specific gravity in most instances with an increase in maturity, as judged by a later harvest date.

These data, obtained during an unusual growing season for Ohio, are not being presented in condemnation of the use of Bordeaux mixture on potatoes under all circumstances, but rather to emphasize the fact

further that the injury which this fungicide is capable of causing may bring about a reduction in yield of many crops whenever disease is not a regulatory factor.

Literature Cited

1. Dutton, W. C. and H. M. Wells. 1924. Some physiological effects of Bordeaux. Proc. Amer. Soc. Hort. Sci. 220: 277-281.
2. Hedrick, U. P. 1907. Bordeaux injury. N. Y. (Geneva) Agr. Exp. Sta. Bull. 287.
3. Horsfall, J. G. *et al.* 1938. Bordeaux injury to tomatoes and its effect on ripening. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bull. 251: 1-34.
4. ———, ———. 1939. Dwarfing of cucurbits sprayed with Bordeaux mixture. Jour. Agr. Res. 58: 911-928.
5. ——— and N. Turner. 1943. Injuriousness of Bordeaux mixture. Amer. Potato Jour. 20: 208-230.
6. Lutman, B. F. 1912. Potato spraying experiments in 1911. Vt. Agr. Exp. Sta. Bull. 162: 36-45.
7. Tilford, P. E. 1933. Some conclusions from nine years of potato spraying. Proc. Ohio Veg. Growers Assoc. 18: 80-83.
8. Sleesman, J. P. and J. D. Wilson. 1943. Comparison of fixed coppers and Bordeaux mixture in the control of insects and diseases on muck-grown Irish Cobbler potatoes. Ohio Agr. Exp. Sta. Bimo. Bull. 28: 173-183.
9. ——— and J. Bushnell. 1945. The yield response of several commercially important potato varieties to the application of Bordeaux mixture. Ohio Agr. Exp. Sta. Bimo. Bull. 30: 73-75.
10. Wilson, J. D. and H. A. Runnels. 1931. Bordeaux mixture as a factor increasing drought injury. Phytopath 21: 729-738.
11. ——— and ———. 1933. Some detrimental effects of spraying tomatoes with Bordeaux mixture. Ohio Agr. Exp. Sta. Bimo. Bull. 18: 4-15.
12. ——— and ———. 1937. The effect of various spray materials on tomato transplants. Ohio Agr. Exp. Sta. Bimo. Bull. 22: 58-65.
13. ——— and W. D. Moore. 1942. Comparison of sprayed tomato plants grown as seedlings in Georgia and Ohio. Ohio Agr. Exp. Sta. Bimo. Bull. 27: 17-25.
14. ———. 1943. Comparative injury to tomato plants by spray and dust materials. Ohio Agr. Exp. Sta. Bimo. Bull. 28: 120-133.
15. ——— and J. P. Sleesman. 1946. Spray materials and the blooming of potatoes. Amer. Potato Jour. 23: 57-64.
16. ———. 1947. Relation between spray treatments and frost damage to potatoes and tomatoes. Ohio Agr. Exp. Sta. Bimo. Bull. 32: 77-82.

CONTROL OF POTATO LATE BLIGHT WITH ANTIBIOTICS[1]

W. A. Hodgson[2]

Laboratory studies at Fredericton on the effects of a number of antibiotics on *Phytophthora infestans* (Mont.) de Bary, the organism causing potato late blight, indicated that certain ones might control this disease under field conditions. Accordingly, a field trial was undertaken during the summer of 1955 in which tests were made with the following antibiotics each of which was applied as a spray at a concentration equivalent to 200 p.p.m. of streptomycin base.

Agri-mycin 100	Supplied by Chas. Pfizer and Co., Inc., Brooklyn, New York, and stated by the manufacturers to contain 15 per cent streptomycin and 1.5 per cent oxytetracycline.
Agristrep	Supplied by Merck and Co. Ltd., Montreal as veterinary grade streptomycin. Assay 1 gm. = 0.664 gm. base.
Dihydrostreptomycin	Obtained as the crude product from Merck and Co. Ltd., Montreal. Assay 1 gm. = 0.775 gm. base.

The experiment consisted of four treatments and an unsprayed control. Each of the above antibiotics was used as a spray to which Dupont Spreader Sticker was added at the rate of one milliliter per gallon. The fourth treatment was a spray of dihydrostreptomycin to which glycerin was added at the rate of 45 ml. per gallon; this treatmenet was included because Gray (1) had reported that glycerin increased the effectiveness of streptomycin against the common bacterial blight of Pinto beans. Each treatment and the control was replicated four times in a randomized block of 20 plots, each plot being approximately 1/60 of an acre in area and consisting of four 60-ft. rows of Green Mountain potatoes. Treatments were applied six times at seven- to ten-day intervals beginning on July 28. The first three applications were made with a single-nozzle portable pressure sprayer at the rate of 150 gallons per acre, whereas the last three were made with a tractor-drawn power sprayer at the rate of 250 gallons per acre. Data on disease incidence and yield were taken from the inner two rows of each plot only.

As very little blight was present when the potatoes were examined on August 26, all the plots were inoculated with a suspension of spores of the fungus on August 27 and again on September 1. Following these inoculations a moderate outbreak of the disease occurred. On September 13 an estimation of the amount of blight present was made by counting the number of infected leaflets on ten plants chosen at random in each plot. The results of this examination and the yield obtained when the plots were harvested on October 13 are shown in the following table:

[1]Accepted for publication November 30, 1955.
Contribution No. 1502, from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario, Canada.
[2]Associate Plant Pathologist, Plant Pathology Laboratory, Fredericton, N. B., Canada.

Treatment	Mean No. of Infected Leaflets per Plant	Yield in Bus. per Acre
Agri-mycin + spreader sticker	6	257
Agristrep + spreader sticker	6	257
Dihydrostreptomycin + spreader sticker	5	252
Dihydrostreptomycin + glycerin	3	253
Unsprayed Control	138	235

All plots were injured by frost on the night of September 13 and further precise readings on the amount of blight present could not be made. An examination of the plots on September 29 showed that in all control plots approximately 80 per cent of the plants were defoliated whereas in the treated plots less than 5 per cent were defoliated. Although all plots treated with antibiotics gave higher yields than the control plots, the differences were not statistically significant. The effective control of the disease given by the antibiotic treatments suggests, however, that greater differences in yield would have been obtained if blight had been present in the plots earlier in the growing season.

The results of this test show that streptomycin and dihydrostreptomycin may be useful for the control of potato late blight under field conditions.

Literature Cited

1. Gray, Reed A. 1955. Increasing the effectiveness of streptomycin against the common blight of beans with glycerin. Pl. Dis. Reptr. 39: 567-568.

THE EFFECT OF NITROGEN FERTILIZATION UPON POTATO CHIPPING QUALITY—CHIP COLOR I.[1]

TOM EASTWOOD AND JAMES WATTS[2]

This paper will present some research findings on the effects of nitrogen fertilization upon potato chipping quality. Because results are from both soil culture and from hydroponic research, it may not be possible to make a direct comparison between the results, but definite trends of valid value may be drawn from these data. Field soil research during the years 1951, 1952, and 1954 will be presented, whereas hydroponic research will be presented from outdoor cultures during the years 1953 and 1954. Because of lack of space, there being 86 tables, the detail experimental data will not be presented. Furthermore, only the chip color data will be presented in this paper; other data will follow in a series of articles in this publication.

EXPERIMENTAL METHODS

Standard methods were used for the crop growth phase of the research for both soil and the hydroponic cultures.

Measurement of chipping color was accomplished by frying potato slices in vegetable oil at an initial setting of 350°F and grading according to fixed standards. The 1951 data were graded by a factory system of 1 to 5, whereas the remaining work was graded against a research laboratory scale of 1 to 15. Grade number 1 was similar in both cases and represented ideal color. The specific gravity was measured during 1951 and 1952 with the National Potato Chip Institute Potato Hydrometer, whereas in 1953 and 1954 a more accurate means, consisting of weighing the tubers in air and water with two accurate scales, was utilized.

Chip taste was accomplished by the use of a consumer acceptance type of panel using a scale of 1 to 5, grade 1 being the best. Only those chips grading from 1 to 4 in color (acceptable research laboratory color range) were tasted. The picric acid - sodium carbonate method was used for the evaluation of the reducing sugar content of the potato tubers. All percentage losses were calculated for both curing storage conditions and for previous cool/cold storage conditions.

Statistical treatment of the experimental data was with the method of analyses of variance.

Sufficient potatoes from a field composite sample were collected to supply at least three 20 to 30-pound samples for chipping tests. One lot, "A" series, was placed directly into curing storage, another lot, "B" series, was held in cool/cold storage for 6 to 9 weeks before being put into curing storage, while another lot, "C" series, was held in the previous cool/cold storage for a period varying from 12 to 18 weeks before being put into curing storage. The succeeding curing storage periods varied from 6 to 8 weeks in duration. The cool/cold storage was a farm type with the temperature being reduced gradually to 40°F. The curing or conditioning storage was held around 70°F.

---

[1]Accepted for publication February 1, 1956.

[2]Horticulturist and Assistant Horticulturist, respectively, Wise Potato Chip Company, Berwick, Pa.

During the curing storage treatment periods of each sample, weekly chipping tests for color, specific gravity, taste and reducing sugar content were conducted during 1951, 1952 ,and 1953. Bi-weekly tests were performed in 1954 for the color, specific gravity and taste. The weekly and bi-weekly tests for color, taste and reducing sugar were conducted on four representative tubers. Eight-pound samples were used for the specific gravity measurements. These were then dried by warm air and returned to the same bag (burlap).

Experimental Results

Chip Color Data for Soil Culture Experiments from 1951 to 1954 and and for Hydroponic Experiments from 1953 and 1954.

1. 1951 Camp Potato Experiment.

In general, chip color was good, which was no doubt related to favorable weather conditions. The slight improvement in chip color with the use of the highest application of nitrogen fertilizer (using 2-12-12, 4-12-12, and 8-12-12 at 1000 pounds per acre) was of doubtful value from a practical standpoint. The potato variety influenced this response to a certain degree as indicated by the significance of the statistical interaction.

Only the two named varieties, Russet Rural and Katahdin, will be discussed in this paper (12 varieties and seedlings were used for the fertilizer study discussed above). The use of extra nitrogen slightly improved the chip color of the variety Russet Rural, but it had no effect upon the variety Katahdin.

2. 1952 Camp Potato Experiment.

The same trends held within the three separate series; that is, within the three groups which had different lengths of previous cold storage treatment prior to the curing storage periods. In this experiment, the three levels of nitrogen used, 40,80, and 160 pounds per acre, had no effect upon the chip color of the four potato varieties utilized,—Kennebec, Nixon Seedling, White Rural, and Russet Rural. The potash applications, 80, 120, and 160 pounds per acre also had no influence on the chip color.

Considerable differences occurred in chip color among the varieties as can be expected. The best average chip color was produced in the Kennebec variety. The seedling and the White Rural averaged second best, whereas the darkest chips were produced by the Russet Rural.

No doubt because of the hot, dry weather the chip color quality was not very good this season.

3. 1952 Penn State Experiment.

Poor chip color quality was obtained in this test with the variety Katahdin. This was no doubt related to the hot, and dry weather which affected this crop. The two levels of nitrogen, 75 and 150 pounds per acre, used in the fertilizer applications had no influence upon the chip color. A limited, but interesting, interaction developed between nitrogen and potash fertilizer levels (150 and 225 pounds per acre) in respect to chip color. However, this response was only significant within the sulfate of potash plots, and there was only a trend within the muriate of potash-

treated potatoes. The use of the lower level of nitrogen improved the chip color when the muriate of potash was employed. Conversely ,the use of the higher application of nitrogen improved the chip color when the sulfate of potash was used.

4. 1954 Penn State Experiment.

The several levels of N fertilization used (0-160-160, 40-160-160, 80-160-160, 120-160-160, and 160-160-160) pounds per acre of (N, P_2O_5 and K_2O) had no effect upon chip color. As can be expected, the location factor affected chip color the most. However, the real reasons for this usual location response are as yet unknown. The potato varieties were Katahdin, Kennebec, and Russet Rural.

5. 1953 Outdoor Hydroponic Experiment.

The lowest nitrate level (1.75 to 3.5 mm.) in the nutrient solution produced the darkest colored potato chips, whereas the higher levels (3.5 to 14.0 mm) produced the lightest colored potato chips. The color grade was only fair at best under the experimental conditions of the relatively high temperatures experienced during the growing season for the varieties Cobbler, Katahdin, Kennebec, and Russet Rural.

6. 1954 Outdoor Hydroponic Experiment.

With the exception of the medium level (8-12 mm) of nitrate-nitrogen, little difference developed in chip color among the four levels of nitrate used, namely, 4-8, 8-12, 12-16, and 16-20 mm in the nutrient solution for the varieties Cobbler, Katahdin, and Russet Rural.

Discussion and Summary

Use of extra N, that is, more than was needed to support adequate potato plant growth and production, did not consistently and definitely improve chip color quality.

The data were weak in the support of a possible interaction between N level and potato variety with respect to chip color.

To date no interaction between N and K_2O levels in the fertilizer has developed to affect chip color.

An interesting observation was the possible interaction between N level and K_2O source in relation to chip color.

The so-called location factor had a much greater effect upon chip color quality than did N fertilization.

Acknowledgments

a. *Cooperating Agencies*

(1) 1951 and 1952 Camp Potato Experiments: E. L. Nixon, Agricultural Advisor, Pa. Potato Growers' Co-op Assn., Coudersport, Pa., and S. D. Gray, Northwest Branch Manager, Amer. Potash Insti., Washington, D. C.

(2) 1952 Penn State Experiment: J. S. Cobb, Agronomy Dept. The Penn State Univ., Univ. Park, Pa.

(3) 1954 Penn State Experiment: F. G. Merkel and Herman Thimm. Agronomy Dept., The Pa. State Univ., Univ. Park, Pa.

b. *Wise Horticultural Research Staff*

(1) Experimental Data: Harry Boyer, Richard Wolfe, Harold Rhone, Edward Schecterly, Mason Hoida, and Wilbur Shoemaker.

(2) Statistical Analyses: Harry Boyer, Richard Wolfe, Adele McHenry, and Edward Hoover.

NEWS AND REVIEWS

FOREIGN POTATOES, THEIR INTRODUCTION AND IMPORTANCE[1]

R. W. HOUGAS[2]

The commercial potato is not native to North America but like many of our important crop plants is an introduction from abroad. The introduction route of the potato to this country is an indirect one which has its beginning in Peru and Chile. Potatoes were important in the agricultural economy of the South American Indians for hundreds of years prior to the Spanish invasion of Peru. Archeological evidence indicating cultivation of the potato in the Andean highlands as early as 200 A.D. has been found. When the Spanish invaded Peru they found a wide array of potatoes being grown by the Inca Indians. Though the invaders found the varied shapes, sizes and colors of the Indian potatoes intriguing they, in their lust for gold, gave only passing consideration to this strange new crop. The food requirements of the invading troops eventually led the Spaniards to utilize the potato in their diet. And, as might be expected, potato tubers found their way to Spain among the shiploads of plunder from the New World. The exact date when this occurred as well as the number of types introduced is unknown. There is historic evidence, however, to indicate that at least one importation reached Spain no later than 1569 and it appears likely that earlier importations were made. By 1600 potatoes were grown in limited quantities in several European countries including Italy, England and Ireland. The Europeans were reluctant, however, to accept this new crop as a foodstuff.

Acceptance of the potato was promoted in various ways. In Prussia, which was among the first of the European countries to grow potatoes in quantity, a succession of rulers beginning with the Great Elector, Frederick William, decreed that potatoes be planted. The first planting under royal edict was in 1651 in the Berlin Lustgarten. King Frederick William I, grandson of the Great Elector, resorted to drastic measures threatening to cut off the ears and noses of all who refused to plant potatoes. His son, Frederick the Great, deserves much of the credit for the successful promotion of potato culture in Prussia. He not only distributed seed potatoes free of charge but issued royal circulars in 1756 and 1757, advising the peasants regarding the culture and storage as well as to recipes for preparing potatoes as a food for man and as feed for animals.

Antione Parmentier, a Frenchman who was fed and learned to like potatoes while a prisoner in Germany during the Seven Years War, was largely responsible for the introduction of potatoes into French agriculture. Upon his return to France, Parmentier obtained permission from King

[1]Accepted for publication November 21, 1955.
[2]Agent, Plant Introduction Section, United States Department of Agriculture and Assistant Professor, Department of Genetics, University of Wisconsin, Madison, Wis.

Louis XVI to plant potatoes in a piece of land known to be quite infertile. The thriftiness of the resulting crop highly impressed the King and his subjects who saw it. When the potatoes were in full bloom Parmentier presented the King with a bouquet of potato flowers. The King responded by placing one of the flowers in his buttonhole and in the evening Marie Antoinette wore a cluster of the flowers in her hair. This endorsement of the potato and that of the various potato dishes served at the King's table were enhanced by placing a uniformed guard on Parmentier's potato plot. Parmentier's considerate removal of the guard at night during the harvest season is reported to have furthered the success of the potato with the King's subjects.

These and other such measures were effective in gradually acquainting the Europeans with the new crop. Hunger and famine, however, were the real persuaders instrumental in increased potato usage in Europe. The 17th and 18th century peasants of the war-ravaged areas learned not only of the high productivity of the potato but also of its immunity to the conqueror's torch which destroyed their fields of grain.

Some confusion as to when the potato eventually reached North America originates through early references to the introduction of the sweet potato (*Ipomoea batata*) as well as to the white potato (*Solanum tuberosum*). It is now generally accepted that the white potato was first brought to this country in 1719 by Scotch-Irish immigrants who established a colony at Londonderry, New Hampshire.

Early American Potato Breeding

Only limited quantities of a few unimproved varieties were grown in North America prior to the last quarter of the 18th century. By 1800 several additional varieties were known and potato production was definitely on the increase.

Little real progress was made in potato breeding prior to 1850, however, either in North America or in Europe. The middle of the 19th century marks the beginning of a period of great potato breeding activity. This acceleration of potato breeding was a direct result of the severe late-blight epidemic which swept over this country and Europe in the years 1843 to 1847. It was this epidemic which destroyed the entire potato crop of Ireland in 1845 bringing starvation to or forcing immigration upon three million inhabitants of the Emerald Isle.

Among the first of the early potato breeders in this country was the Reverend Chauncey Goodrich of Utica, New York. Goodrich believed that the potatoes had been weakened in vigor through long-continued asexual propagation and thus became susceptible to late-blight. Since he was convinced that they could be rejuvenated only through sexual production he set forth to prove his convictions by planting true potato seed and growing the resulting populations of new potato seedlings. Goodrich early recognized the desirability of obtaining germ plasm in addition to that found in the varieties being cultivated at the time. In 1851, in response to his requests for new breeding stocks, he received a small quantity of South American potatoes through the American consul in Panama. Among this lot was a rough, purple-skinned Chilean variety which Goodrich aptly named Rough Purple Chili. The impact of this

single foreign introduction on potato breeding is well established. Through such outstanding offspring as Garnet Chili, Early Rose, Brown Beauty, Early Ohio, Early Beauty of Hebron and Burbank's Seedling this introduction has entered into the parentage, in the last hundred years, of more than 250 European and American varieties. Just how other new introductions were utilized in the period from 1850 to 1900 is impossible to determine, since most of the breeders active during this time gave little consideration to the recording and publication of varietal pedigrees.

Though many of the varieties developed by the breeders of the 19th century have now disappeared from general agricultural production a few of the best adapted, particularly Irish Cobbler, Russet Burbank, White Rose, Triumph, Green Mountain, Russet Rural, Red McClure and Early Ohio, are still very important commercially. It is of interest to note that no new varieties of consequence other than clonal selections were released during the period 1900 to 1932.

Modern American Potato Breeding

The variety Katahdin was released to the potato growers of the United States, through the federal potato breeding program, in 1932. The release of this variety marks the beginning of an era, extending to date, in which the breeding and release of American potato varieties have largely been through state, federal and cooperative state-federal breeding programs. Much emphasis has been placed by the modern breeder on developing well-adapted varieties resistant to the economically important diseases of the potato.

Foreign introductions have played an important role in modern potato breeding. A survey of the pedigrees of the 70 varieties developed and released in the United States since 1932 reveals that 24 different foreign introductions enter into the combined parentages of these varieties. These 24 selections were obtained from 13 countries (Austria, Bolivia, Brazil, Chili, Costa Rica, England, Esthonia, France, Germany, Netherlands, Mexico, Poland, Sweden).

The majority of the foreign parental stocks which have been employed by the modern American potato breeders were introduced from Europe. Two of these European importations, the English variety Sutton's Flourball and the Polish variety Busola have played particularly imposing roles. Sutton's Flourball appears in the pedigrees of 62 of the new American varieties; Busola enters into the pedigrees of 61. The heavy utliization of these two varieties is, in large measure, due to the extensive use of the variety Katahdin as a pollen parent. Katahdin, developed and released by the National Potato Breeding Program of the United States Department of Agriculture, is an elite selection from the cross (Aroostook Wonder ♀ x Sutton's Flourball ♂) x (Rural New Yorker No. 2 ♀ x Busola ♂).

It is difficult and perhaps impossible to determine with exactness all the superior characters which the varieties Sutton's Flourball and Busola have contributed to American potato breeding. Both are known to produce fertile pollen. This character, without doubt, is one of the primary factors which determined their initial selection as parents since the old American varieties available to 20th century breeders produced, with few exceptions, no or very limited quantities of functional pollen. These two varieties are

also known, however, to possess other desirable characters including good cooking quality, resistance to disease and good yielding ability.

Two German varieties, Jubel and Hindenburg, have been much used in breeding for resistance to the disease of the potato tubers known as common scab. Nine scab-resistant American varieties (Antigo, Cayuga, Cherokee, Menominee, Ontario, Osage, Redkote, Seneca, Yampa) have been developed through use of one or both of these two introductions from Germany.

Several foreign selections have been utilized in breeding for resistance to late-blight. Twelve late-blight resistant varieties (Ashworth, Chenango, Cortland, Empire, Essex, Fillmore, Glenmeer, Harford, Madison, Placid, Snowdrift, Virgil) have been developed from one or more of three selections of the wild, late-blight-resistant Mexican species *Solanum demissum* (Fig. 1). Nine other varieties (Boone, Cherokee,, Delus, Early Gem, Kennebec, Merrimack, Plymouth, Pungo, Saco) derive their resistance to late blight from the so-called "W race" selections (*S. demissum-S. tuberosum* hybrids) from Germany.

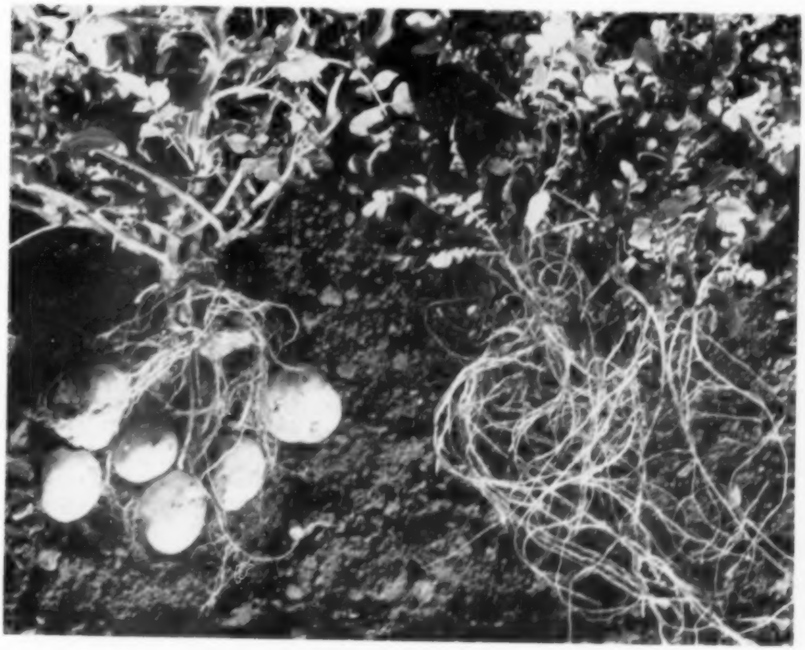

FIGURE 1.—Late-blight resistant potatoes.

Left to right:

One of the twenty-one late-blight resistant American varieties developed through hybridization of the commercial potato with the late-blight resistant species, *Solanum demissum*.

The wild, late-blight resistant, Mexican species, *Solanum demissum*; the tubers of this species are very small and are not generally formed under most U.S. field conditions.

The recently released variety Saco obtains its immunity from latent, or X, virus of potato from the Chilean variety Villaroela.

Various other characters have been incorporated in present-day American varieties through use of foreign introductions as parents. A detailed listing of this information will be published at a later date.

Introduction and Preservation of Breeding Stocks

Of the many crop plants currently being hybridized in the United States there are but few that have not been improved through the use of imported breeding stocks. The search for and introduction of all foreign plants, including potatoes, has been materially assisted by the Plant Introduction Section (formerly Division of Plant Exploration and Introduction) of the United States Department of Agriculture. This agency, established in 1898, has introduced, catalogued and distributed to scientific workers more than 220,000 individual plant introductions. An interesting and comprehensive review of this work, including the contributions of the Plant Introduction Section to plant improvement in the United States, was recently published by W. H. Hodge and C. O. Erlanson in Advances in Agronomy 7:189-211 entitled "Plant Introductions as a Federal Service to Agriculture".

Two means, for the most part, have been used to procure and introduce plants from abroad: (1) Direct requests to foreign laboratories or stations for certain of their breeding stocks, and (2) organized expeditions, led by specially trained plant collectors, to various areas of the world. Both means have been used in obtaining new potato selections. Most of the direct requests have been to the several potato improvement centers of Europe; all of the organized collecting expeditions for potatoes have been to Mexico and Central and South America.

A huge diversity of wild and cultivated potatoes (tuber-bearing *Solanaceae*) occur in the mountainous areas of Mexico and southward through Central America, Venezuela, Columbia, Equador, Peru, Bolivia, Chile and Argentina. The northernmost range of the endemic tuber-bearing *Solanaceae* is southwestern United States where two small-tubered species, *Solanum fendleri* and *Solanum jamesii* are found. The exact number of tuberous *Solanum* species which exists in the vast, relatively unsearched areas of Mexico, Central America and South America is unknown; at present more than 240 species have been found and named.

There is much variation in the numerous tuber-bearing species of *Solanum*. There is scarcely a portion of the plant that does not exhibit a multiplicity of types as to size, form and color. Some species have large, simple leaves resembling in some stages of growth those of the ground cherry; others have narrow, pinnate leaves giving the over-all plant the appearance of the garden marigold (Figure 2). The flowers occur in an array of colors from white through crimson to deep purple with an assortment of patterns as well. Tubers are unusually variable in shape and color. Both skin and flesh may be slight to heavily pigmented with yellow, red or purple and both may be solid or parti-colored. Tuber shapes may range from smooth spheres to rough, knobby, elongate forms and occasionally include grotesquely twisted types.

Variability of equal magnitude for many characters such as resistance

FIGURE 2.—Leaves of five tuber-bearing *Solanum* species.

Left to right:

Solanum demissum—The well-known late-blight resistant species from Mexico.

Solanum pinnatisectum—Another Mexican species; highly resistant to late-blight and to Southern bacterial wilt.

Solanum acaule—A species native to the high altitudes of Bolivia and Peru; highly resistant to frost and immune to potato X virus.

Solanum simplicifolium—A species which occurs in Argentina and Bolivia; hypersensitive to potato Y virus.

Bottom:

Solanum tuberosum—The commercial potato variety Katahdin.

to insects, diseases, drought, and cold exists among and between the various wild and cultivated *Solanum* species. These characters, and others not found in our commercial potato varieties, are those sought by potato breeders in their work of improving the crop. For many years potato breeders recognized the desirability of having a readily available source of the many tuberous *Solanum* species. Some breeders individually attempted to maintain extensive collections of foreign breeding selections, varieties and species but ultimately found the task of maintenance too burdensome. These individual, abortive attempts at maintaining a collection of *Solanum* germ plasm led U.S. potato breeders to make a united appeal for the establishment of a germ plasm center for the tuber-bearing species of *Solanum*.

The entire roster of the many individuals who contributed time and effort in promoting this development is too lengthy to list here. Special

mention should be made, however, of those who conceived the idea and provided the sustained impetus which resulted in the establishment of the Inter-Regional Potato Introduction and Preservation (IR-1) Project. The late Professor Donald Reddick of Cornell University was the first American potato breeder to use the wild, late-blight resistant Mexican species, *Solanum demissum*, effectively in his potato improvement program. It was his pioneering efforts which provided other American potato breeders with a precise insight to the potential value of the wild, tuber-bearing *Solanum* species. He, along with F. A. Krantz, H. Mattson, J. C. Miller, G. H. Rieman, F. J. Stevenson, H. O. Werner, E. J. Wheeler and others, met in conference, discussed the matter in considerable detail and drafted the initial project proposal. The proposal, with a request for support, was submitted to the head of the Division of Plant Exploration and Introduction (now Plant Introduction Section) of the United States Department of Agriculture and to the directors of the twelve land-grant state agricultural colleges of the North Central Region (North Dakota, South Dakota, Nebraska, Kansas, Missouri, Iowa, Illinois, Indiana, Ohio, Michigan, Minnesota, and Wisconsin).

After a thorough review by the federal and state administrators a joint budget, modest but adequate to initiate the program, was provided in late 1948. These grants were through funds of the Research and Marketing Act of 1946.

It was decided that Wisconsin would be a desirable location for the *Solanum* collection. The Wisconsin Agricultural Experiment Station, upon request, agreed to accept the project and to provide some of the necessary physical plant. The project operated under this cooperative arrangement until 1950, when the 36 states of the other three land-grant college regions entered into and began contributing toward this new project. Since 1950 the program has been cooperatively supported by the 48 states and the United States Department of Agriculture (Figure 3).

Before passing on to the work of the project, credit should be given to G. H. Rieman, leader of the Wisconsin potato breeding project, and to F. A. Krantz, leader of the Minnesota potato breeding project, who have each contributed unceasingly of their time and effort, from the very outset, to assure the success of this new development. And finally, without the wholehearted support and administrative guidance of C. O. Erlanson, head of the Plant Introduction Section, it is doubtful that the initial proposal of the potato breeders would have received favorable administrative consideration.

Two of the chief obstacles which confronted the early individual attempts to maintain *Solanum* collections also seriously hampered the early work of the cooperative potato introduction center in Wisconsin. These obstacles were the loss of stocks through infection by disease, especially the several *Solanum* virus diseases, and the lack of tuberization of stocks requiring a short-day length (12 hours or less of daylight).

With the increased support in 1950, resulting from the full cooperation of all 48 states, it was possible to begin erection of greenhouses for propagation of the introduced *Solanum* stocks. By early 1952 a considerable portion of the necessary greenhouse facilities was completed and equipped. The balance of the greenhouse needs are currently nearing completion. Greenhouse propagation has almost completely overcome the two previously

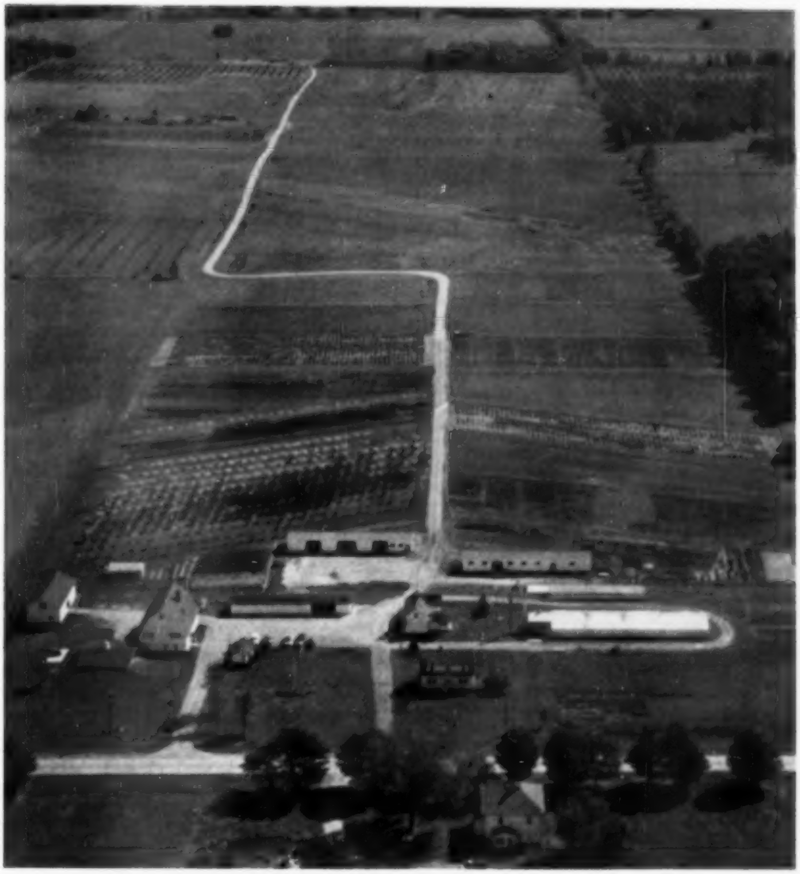

FIGURE 3.—Field headquarters of the Inter-Regional Potato Introduction Project located at the Branch Agricultural Experiment Station, Sturgeon Bay, Wis.

mentioned obstacles since diseases can be much more effectively controlled and tuberization of short-day types can be obtained by fall and winter plantings.

In the beginning, the Inter-Regional Potato Collection was largely comprised of several hundred selections of approximately 25 different species. Most of the species were those collected by D. S. Correll, of the Plant Introduction Section, who was sent to Mexico at the request of potato breeders to search for additional *Solanum* germ plasm resistant to late blight. Selections of six species, introduced through this expedition in addition to numerous new selections of *Solanum demissum*, have proven highly resistant to late blight. The worth of the collection has since been materially augmented by the generous contributions of stocks made, upon

request, by several foreign laboratories, especially the Potato Genetics Station at Cambridge, England, the Scottish Potato Breeding Station at Edinburgh and the Max Planck Institute for Plant Breeding in Germany. Recently several interesting new types have been received from Carlos Ochoa of Lima, Peru. The program of introducing new potato stocks is a continuing one. Within the last year potato seeds and tubers were introduced from 12 foreign countries (Argentina, Austria, Belgium, Canada, Chile, Costa Rica, England, Germany, Netherlands, Paraguay, Peru, Scotland).

The collection presently totals more than 2800 clones and seed lots and includes 146 varieties of the cultivated potato, 81 species and numerous species hybrids. All of the stocks in the collection are available not only to potato workers throughout the United States but also to potato workers in other countries of the world. Catalogues listing the available stocks, along with pertinent information concerning each introduction, are periodi-species hybrids. All of the stocks in the collections not only to potato workers throughout the United States but also to potato workers in other countries of the world. Cataloques listing the available stocks, along with distributed pertinent information concerning each introduction, are periodically distributed to investigators here and abroad. Stocks are shipped annually to nearly every state engaged in potato research. Shipments abroad have increased steadily. Last year shipments were made to two territories (Alaska and Puerto Rico) and to 19 foreign countries (Argentina, Australia, Belgium, Brazil, Canada, Chile, Denmark, England, Germany, Indonesia, Israel, Japan, Netherlands, New Zealand, Pakistan, Peru, Portugal, Sweden, Tasmania).

Some of the recent additions to the collection which are currently of interest to American investigators are: (1) Selections of *Solanum andigenum* found, through researches in England and Netherlands, to be highly resistant to the golden nematode, (2) hybrids of the commercial potato with *Solanum andigenum*, introduced from Germany, which possess promising resistance to late blight, (3) selections of *Solanum acaule* possessing high frost resistance and immunity to potato X virus, (4) selections of *Solanum demissum* known to carry more resistance to late blight than *Solanum demissum* selections previously used in breeding, (5) selections of *Solanum stoloniferum* which carry resistance to late blight as well as immunity from potato Y virus, and (6) selections of *Solanum pinnatisectum* which possess high resistance to late blight and high resistance to Southern bacterial wilt.

Stocks such as those listed above provide potato breeders with the raw materials needed to develop better potato varieties for modern agriculture. The establishment of the new tuber-bearing *Solanum* center provides a continuing source of readily available germ plasm for many American investigators engaged in potato research. Access to this expanding wealth of plant materials may be expected to promote advances not only in breeding but also in basic botanic sciences such as taxonomy, cytology and genetics.

USDA-DEVELOPED BLADELESS POTATO DIGGER SHOWS PROMISE

A potato-digging, rotating rod, developed to replace the customary digger blade on potato harvesting machinery, has demonstrated superior efficiency in U. S. Department of Agriculture experiments.

Results of preliminary tests with this bladeless digger (the rotation of the horizontal rod lifts potatoes from the soil onto the apron of digger or harvester) have aroused the interest of growers and the machinery industry. Two potato-machinery manufacturers currently are experimenting with their versions of the new digger in Florida, where early-potato harvesting is underway.

The experimental bladeless digger represents a research modification of a commercial two-row blade-type digger, using the rotating-rod mechanism from a rotary rod weeder, standard tillage and weed control implement. This modified potato digger was developed by A. H. Glaves, USDA research engineer, at the Red River Valley Potato Research Center, East Grand Forks, Minn. (Figure 1.)

FIGURE 1.—Bladeless potato digger shows promise.

In the new machine, a power-driven ⅞-inch square digger rod replaces the digger blade of conventional equipment. The rod rotates slowly through the soil just below the level of the potatoes, lifting them onto the conveyor apron of the digger.

Experimental use of this digger on 70 acres of potatoes at the East Grand Forks Center has proved that:

(1) It can successfully operate under soil conditions ranging from dry-cloddy to wet-sticky;

(2) It digs potatoes with a minimum of vine-clogging, even when vines are not shredded by roto-beating (a common practice) prior to digging;

(3) It feeds potatoes freely and uniformly onto digger or harvester apron, causing little spill-out loss. Loss of potatoes that roll out beyond the sides of the apron is common with blade diggers when the soil is moist and blades tend to clog with dirt.

(4) It not only digs potatoes but picks them up from a previously-dug windrow.

(5) All digger parts performed well with no evidence of excessive wear.

Glaves is now planning extensive tests to determine how well the bladeless digger can perform in stony soils and how it compares with standard blade diggers in breaking up clods. The experimental digger will also undergo engineering studies to determine the most efficient rotating speed for the rod in terms of forward speed of the digger, and durability.

Development of the digger stemmed from the cooperation of a potato-machinery manufacturer who last year loaned to the Center for experimentation a two-row digger, and rotary rod weeder parts. It typifies the cooperative program that had led to development of many recent potato machinery and handling improvements. Cooperating in the research program at the East Grand Forks Center are the Agricultural Research Service and Agricultural Marketing Service of USDA, the North Dakota and Minnesota Agricultural Experiment Stations, the Red River Valley Potato Growers Association, and the potato-machinery industry.

DUTCH POTATO ATLAS

This beautifully illustrated atlas contains a description and illustrations showing leaves, tubers, flowers and sprouts in full color of 46 potato varieties currently under cultivation in Holland.

The authors, Ir. J. A. Hogen Esch, Dr. F. E. Nijdam and Dr. H. Siebeneick have condensed the descriptions of the important botanical and horticultural characters which identify the varieties as well as information on disease resistance, utilization and cooking quality, into one page, for each variety.

The Atlas is loose-leafed making it easy to insert additional pages, which will be published annually, describing the new varieties that are developed.

In addition to the Dutch text, translations are available in French, English and German.

This Atlas should be of value to importers, breeders and growers of potatoes in many countries.

The price is 69/ (Shillings) or U. S. $9.50. Published by H. Veenman & Zonen - Wageningen, The Netherlands.

SEVENTH ANNUAL UTILIZATION CONFERENCE

Potato processors, marketing specialists and research workers will convene at the University of Maine, Orono, Maine, on August 6, 7, 8, for the Seventh Annual Potato Utilization Conference. Persons from all over the country, who are interested in this important and fast growing development in the potato industry, will spend two days at the University of Maine discussing important phases of this industry as well as related marketing problems.

The conferees will also go to Presque Isle for a tour of the Maine Agricultural Experiment Station's potato research farm, Aroostook Farms.

The Monday morning program includes a report on potato irradiation, potato flakes, and the relation of chemical composition to mealiness. Sprout inhibition, storage for chip manufacture, loading methods and protective services for potatoes in winter will be discussed in the afternoon. The evening session will be devoted to food and drug regulations on fresh and processed potatoes.

The Tuesday morning program will feature discussions on potato marketing, the effect of waxing on potatoes, and the potato future or outlook. The afternoon program will be devoted to discussions on measuring processing quality, potato chip problems and research development with potato chips.

The conferees will then enjoy a trip to famous Mount Desert Island and Cadillac Mountain followed by a lobster dinner.

The last day of the Conference will be devoted to a trip to Aroostook County, the largest potato county in the country, and inspection of potato research at the Experiment Station Farm.

For details, contact Dr. M. W. Meadows, University of Maine, Orono, Maine.

University Microfilms
313 North 1st St
Ann Arbor Michigan